Corrosion Research - Statistical Analysis of Pitting Data and 3013 Lifetime Projections

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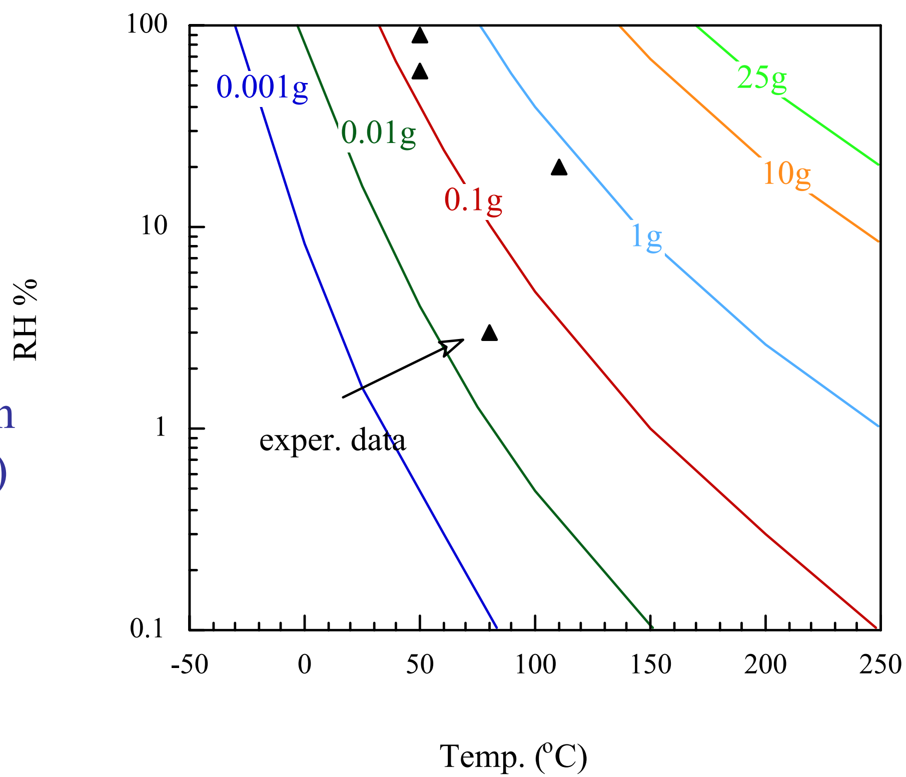
Materials / Environments

- ❖ Non-weld Samples of Stainless Steel 304, 304L, 316L
- ❖ GTA Samples of Stainless Steel 304, 304L, 316L
- ❖ Laser Weld Samples of Stainless Steel 304, 316

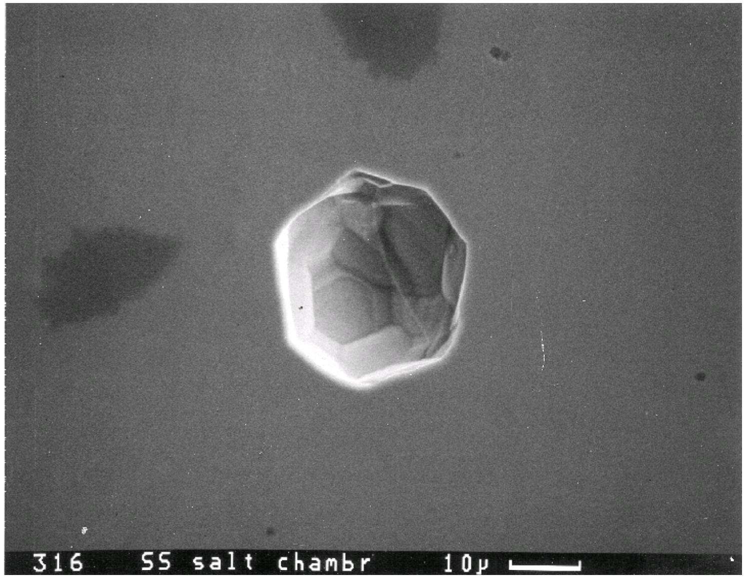
all welds made by MST-6 to Rocky Flats specs.... autogenous welds

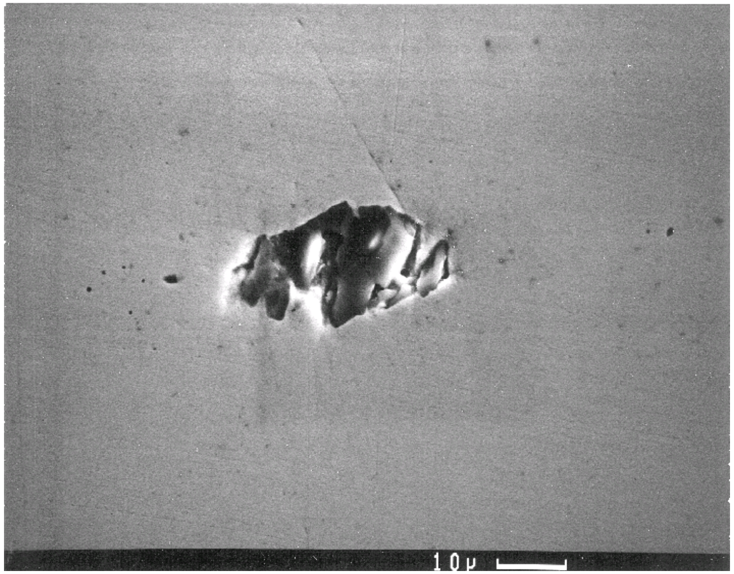
Samples are polished to a mirror finish and then exposed to NaCl (crystalline) as a function of time and temperature:
T= 50°, 80° C
t= 3, 6, 9 weeks

Relative Humidity Isobars vs. 3013 Water Content (2700 cm^3) Assumes all water in the can is available is available to influence the relative humidity (all water may vaporize)



Pit Morphology

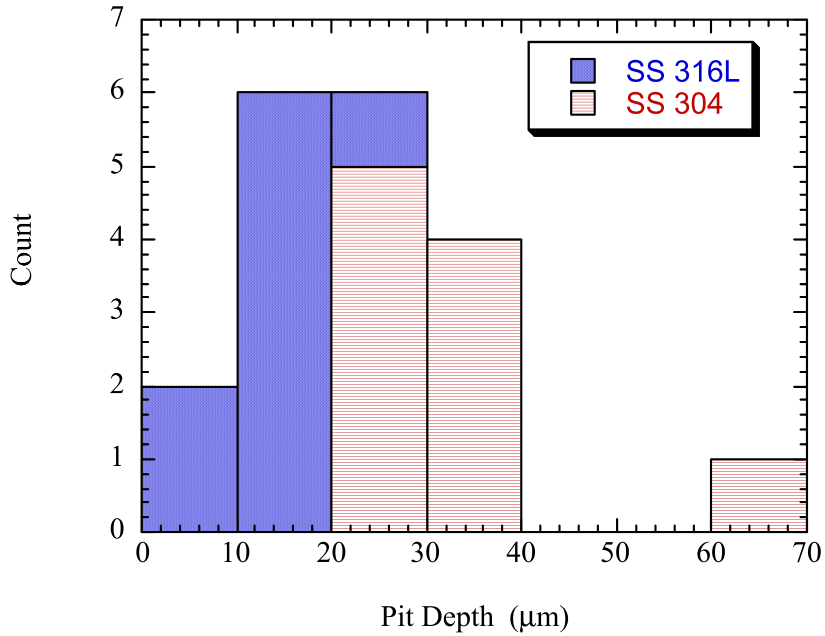


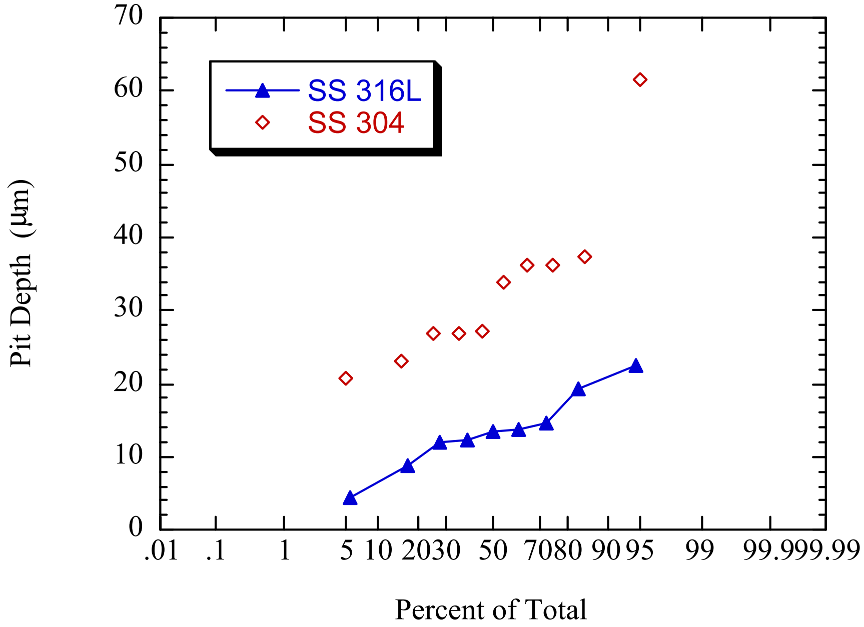


In analysis, for round pits depth is taken as the radius. For nearly round pits, the area is measured from which an equivalent radius is then can then be calculated assuming the pit was spherical.

Experimental Pitting Data, Examples

Stainless Steels 304/316 & Laser Welds; 3% RH, 80º C (2,897 ppm H_20), 3 weeks





Though a similar number of pits were observed in each sample, distribution of pits in SS 304 is shift to greater depths

Extrapolation of Experimental Data in Space and Time

From the GEV it may be shown that the mean maximum pit depth (μ_{max}) over a period of time (t) is given by:

$$\mu_{max}=(u+\alpha/k)t^{b}-(\alpha M^{-k}t^{b})/k\cdot\Gamma\{1+k\}$$

where M=A/a, A is the interior area of the 3013, a is the exposure sample area, and b describes the a nonlinear pit growth rate (assumed 0.5, decreasing with time).

Fit of GEV results in determination of -

α: the scale parameter

k: shape parameter

u: location parameter

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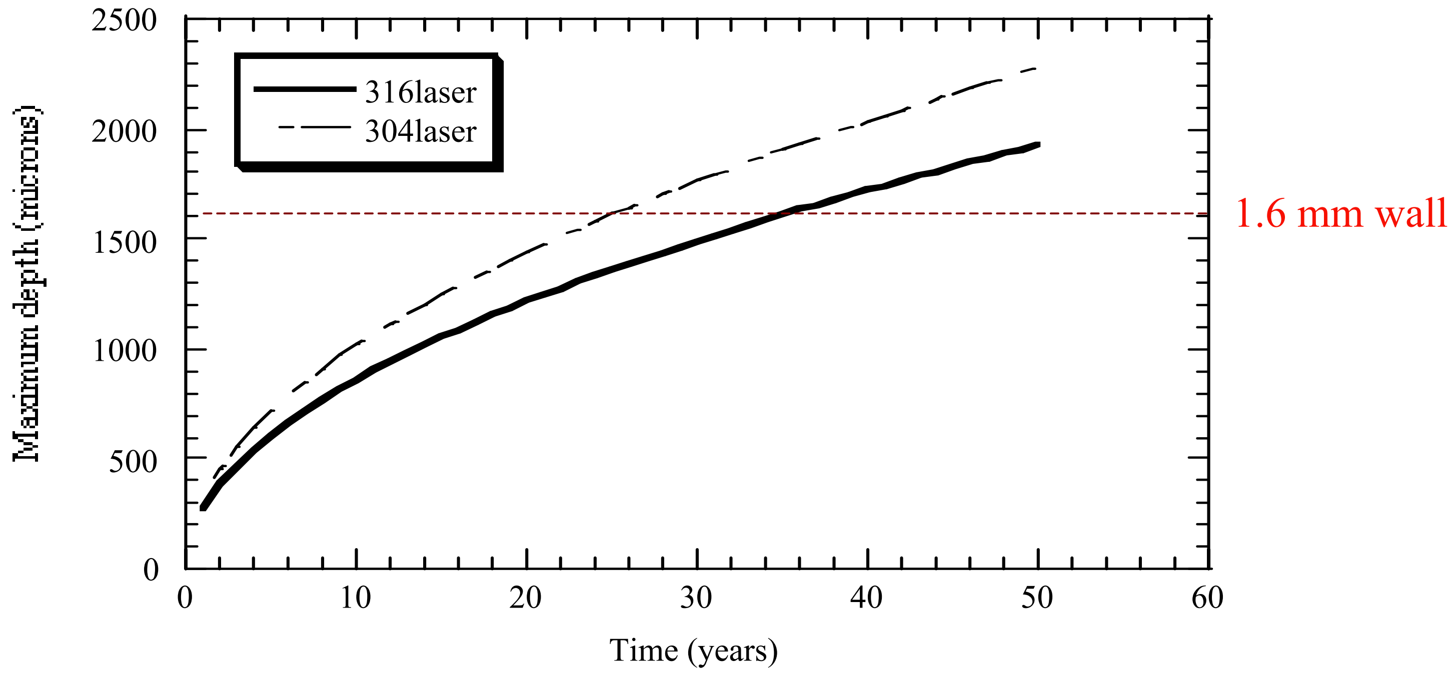
GEV Max Pit Depth Curves

Low Humidity exposure to NaCl 80° C



GEV - Summary

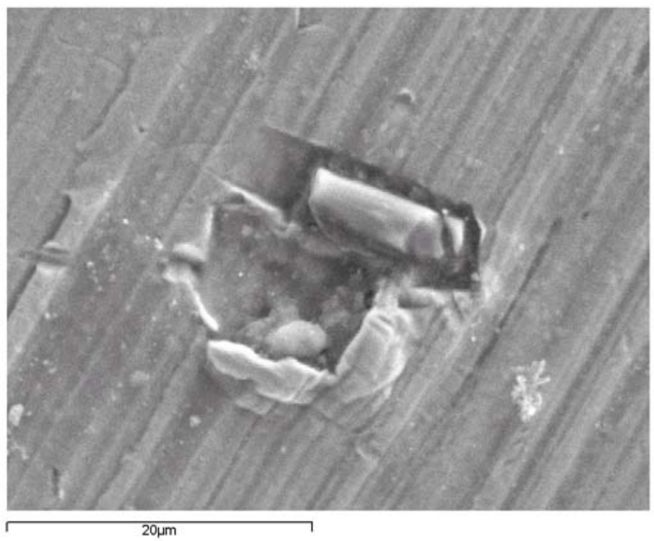
Penetration Rates for 3013 (T< 100^o C)*

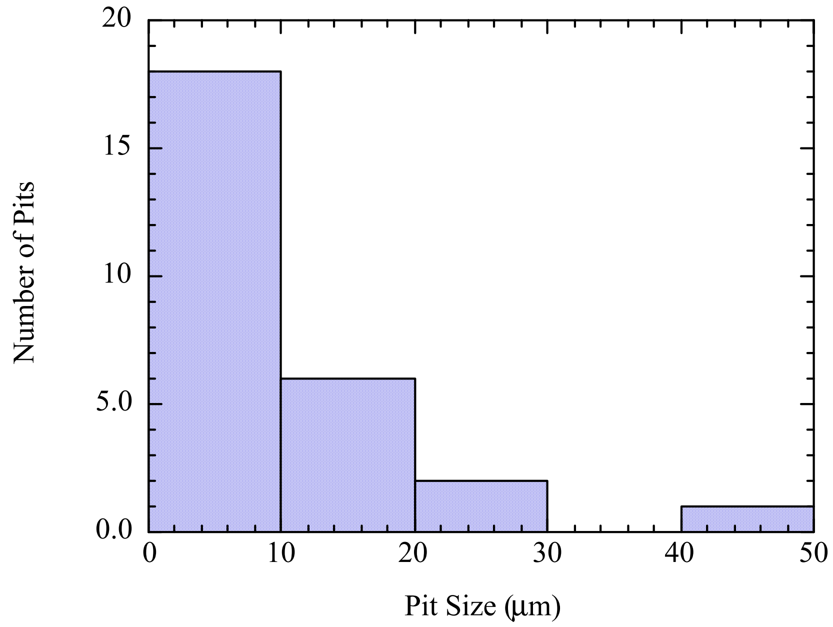
material	**low humidity (3% RH)**	**high humidity (90% RH)**
304	> 50 yrs.	-
304 laser	25 yrs.	-
304 GTA	>50 yrs.	-
316L	>50 yrs.	10 yrs.
316L laser	26 yrs.	10 yrs.
316L GTA	-	7.5 yrs

* based on laboratory experiments, for T> 100^o C it is anticipated that the time to penetration will increase

GEV Extrap. of Surveillance Can Data

Small Scale Cans with L. Worl

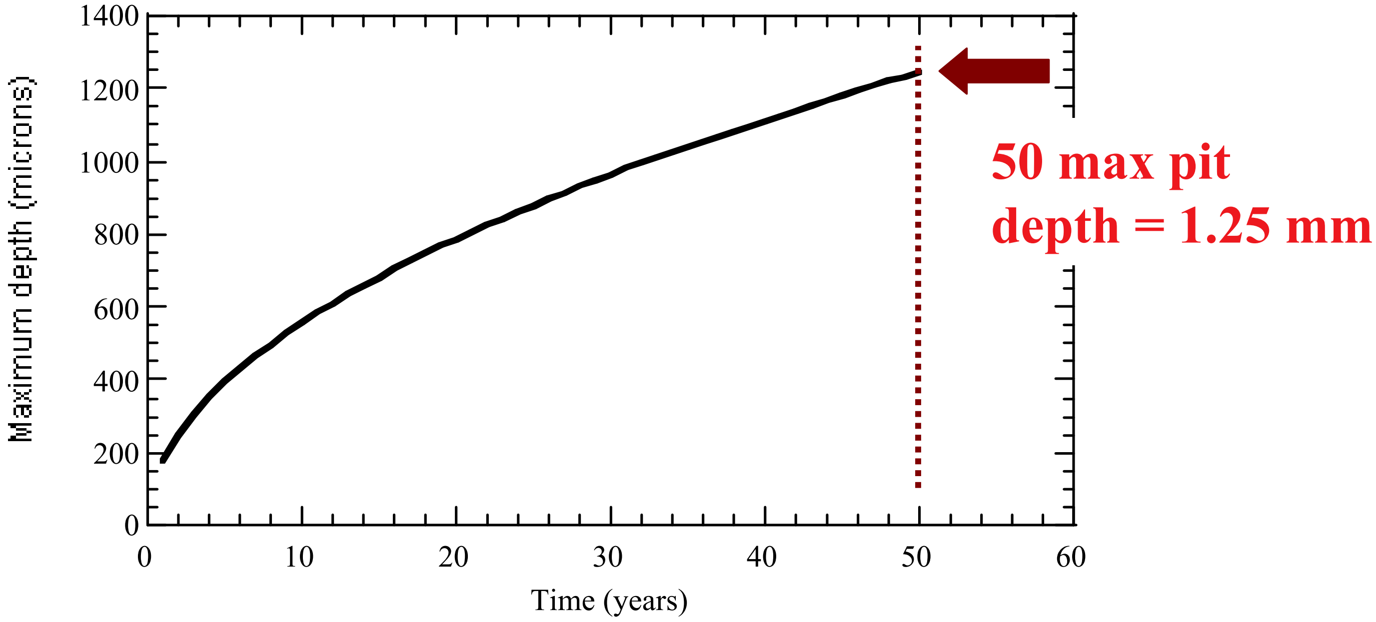




bulk 316L (non-weld)
%RH - ?

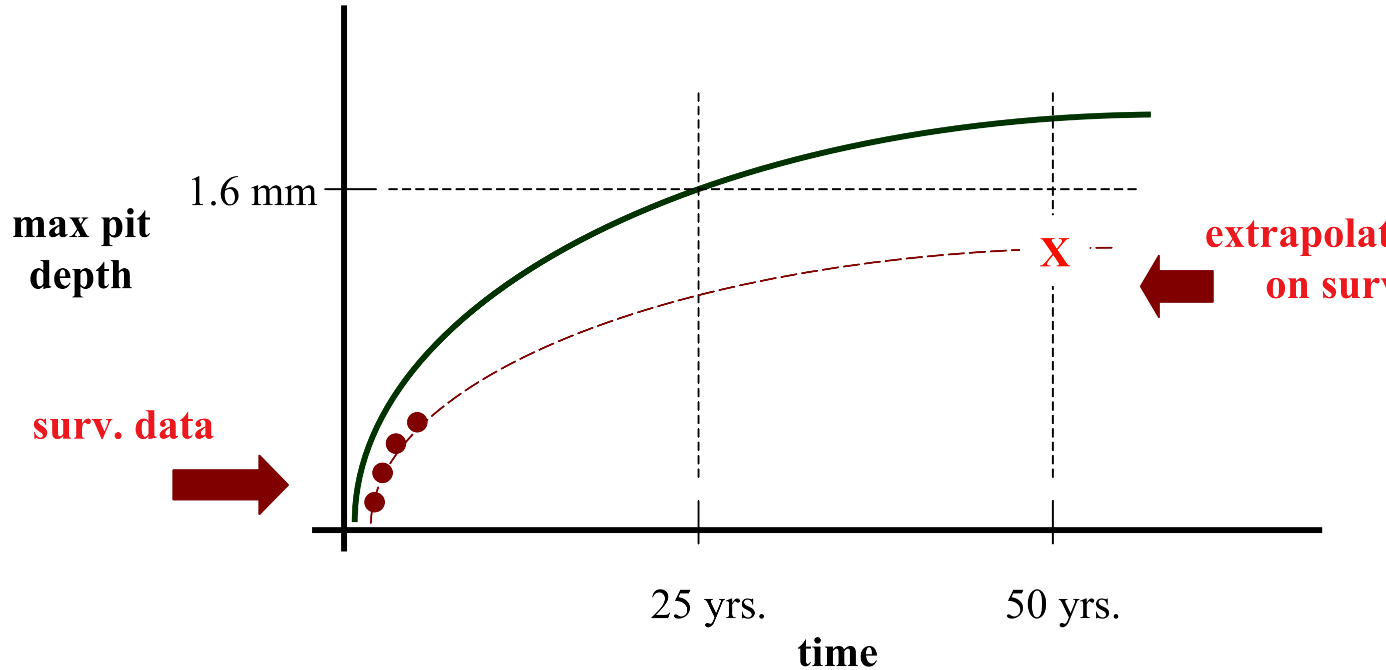
GEV Extrap. of Surveillance Can Data

Small Scale Cans with L. Worl



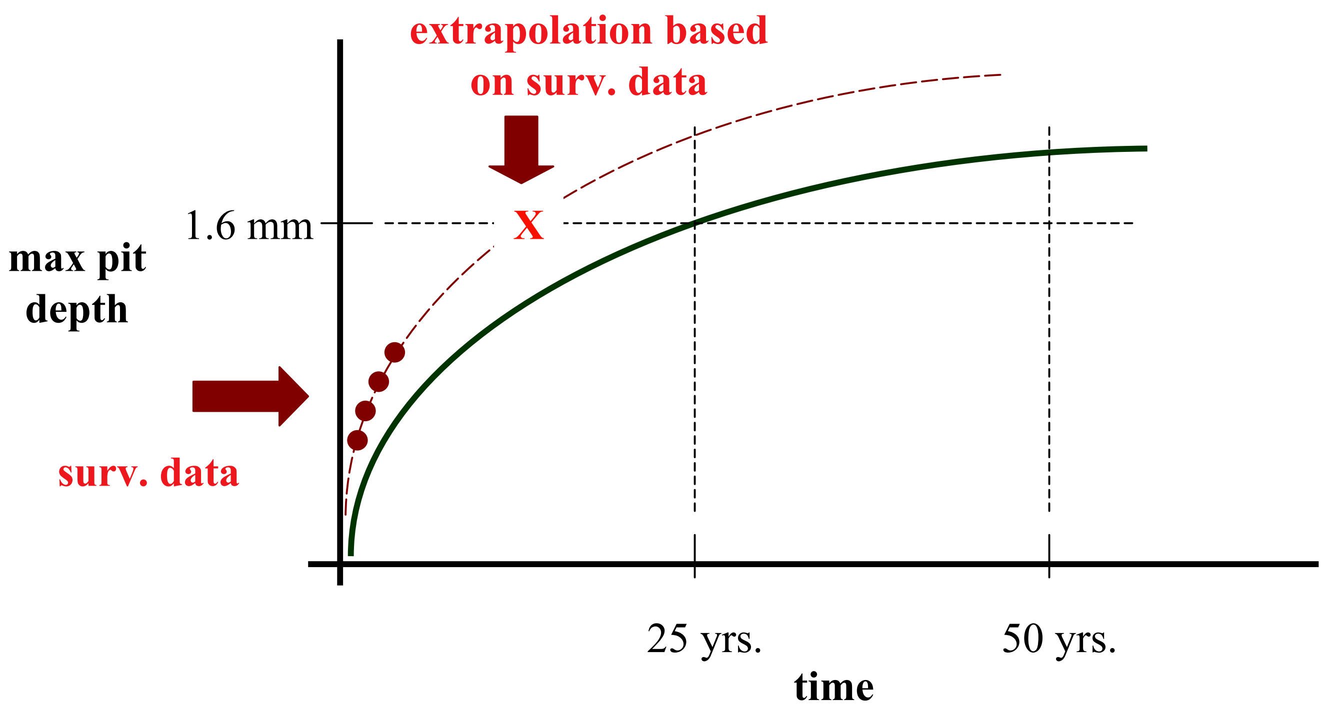
Time to Penetration for this can would be 82.5 yrs.

Using GEV Max Pit Depth Curves in Surveillance



Surveillance data predicts that this class of containers will not fail before projected GEV life and 50 yr. anticipated life

Using GEV Max Pit Depth Curves in Surveillance



Surveillance data predicts that this class of containers will fail well before GEV projected life

Implementation - SRS

As it pertains to failure of 3013 via pitting corrosion .....

Objectives for SRS Lead Surveillance Program:

- **establish a method for categorizing containers based on NaCl/H_2O content**
- **establish a time table for evaluating containers based on lifetime projections**
- **establish methods for measuring critical pit sizes (based on GEV)**
- **establish methods for analyzing pit data within the context of GEV projections**
- **establish protocol for adjusting surveillance schedule based on analysis of data (i.e.. is increased or decreased surveillance necessary).**